Some Notes on the Hawaiian Monk Seal

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UP TO 1958 the collections of the British Museum (Natural History) possessed neither skeletal material nor skin of the Hawaiian or Laysan monk seal, *Monachus schauinslandi* Matschie 1905. Indeed the only remains of this animal in Europe until now have been those brought back by Dr. Schauinsland, amongst which was the skull of the seal later named after him by Matschie (Matschie, 1905). The stuffed skin of this animal is in the Bremen Museum and the type skull is in the Zoological Museum in Berlin, no. 32795 (Wahlert, 1956). So it was with great pleasure that we received, in the summer of 1958, through the kindness of Mr. Vernon E. Brock, then director of the Territorial Division of Fish and Game, Honolulu, Hawaii, a young male monk seal from Laysan Island that had been shipped complete and frozen to this country. The animal was thawed, injected with coloured gelatin in the vascular system, and dissected after fixation, but unfortunately the tissues were too poorly preserved for any accurate histology.

DESCRIPTION

The seal is young, has a nose-to-tail length of 163.5 cm. (5 ft. 6 in.) and weighs 74.4 kg. (164 lb.) complete. Kenyon and Rice (1959) give the estimated weights of recently weaned pups as from 95–160 lb. The present animal was caught June 4, 1958, and as it must have been very near to being weaned, its probable date of birth must have been about April 30. Although the weight is a little high for a recently weaned pup, the animal is in very good condition and is unlikely to have been a yearling, as yearlings are relatively thin and do not reach the weight and condition of pups that have been feeding from their mothers. Similarly the state of the epiphyses and the obvious youth of the skeleton make it unlikely that it is from a 2-year-old animal. The age of the present animal is therefore estimated to be about 5 weeks (the thymus is large and weighs 32.5 g.). The coat is dark silvery grey dorsally, on the top of the head, on both sides of the fore and hind flippers, and on the dorsal surface of the tail. Laterally the grey shades to silvery white ventrally. The hind flippers are a little lighter grey on the inner side towards their insertion. There are also lighter patches round the eyes and surrounding the insertion of the supraorbital vibrissae, and along the upper lip. The lower jaw is light in colour. On the back the hairs are dark grey with a white tip. This white tip becomes longer towards the belly so that the ventral hairs are white with a short dark base. The moustachial whiskers are in five rows on each side of the nose, the upper row having four whiskers and the other rows approximately nine in each. The whiskers are dark brown at the base, shading to straw colour at the tip; they are oval in cross section and are not beaded as in *Phoca* (Fig. 1).

The tongue has a notch in its anterior end. The length of the small intestine is approximately 57 ft. The only food remains in the stomach are fish bones and skin and these have been identified as being most probably from the puffer fish, *Arothron meleagris* (Lac.), which is a poor swimmer usually found near coral formations. Nematodes, a small cephalopod beak, and an isopod are also present in the stomach. The nematodes have been identified as *Contracaecum turgidum,* a species previously described from this seal, and the isopod as *Livoneca* sp., usually found as an ectoparasite on fish and probably ingested attached to a fish. In the small intestine there are remains of a tapeworm. It is not in a sufficiently good condition to be identified exactly, but is probably *Diphyllobothrium* sp.

The skin and skeleton of this seal are in the collections of the British Museum (Natural History), the registered number of the skin being 58.521, and that of the skeleton 1958.11.26.1.

OSTEOLOGY

The skeleton of *M. schauinslandi* has not previously been described and although it is attempted here to fill this gap the description and

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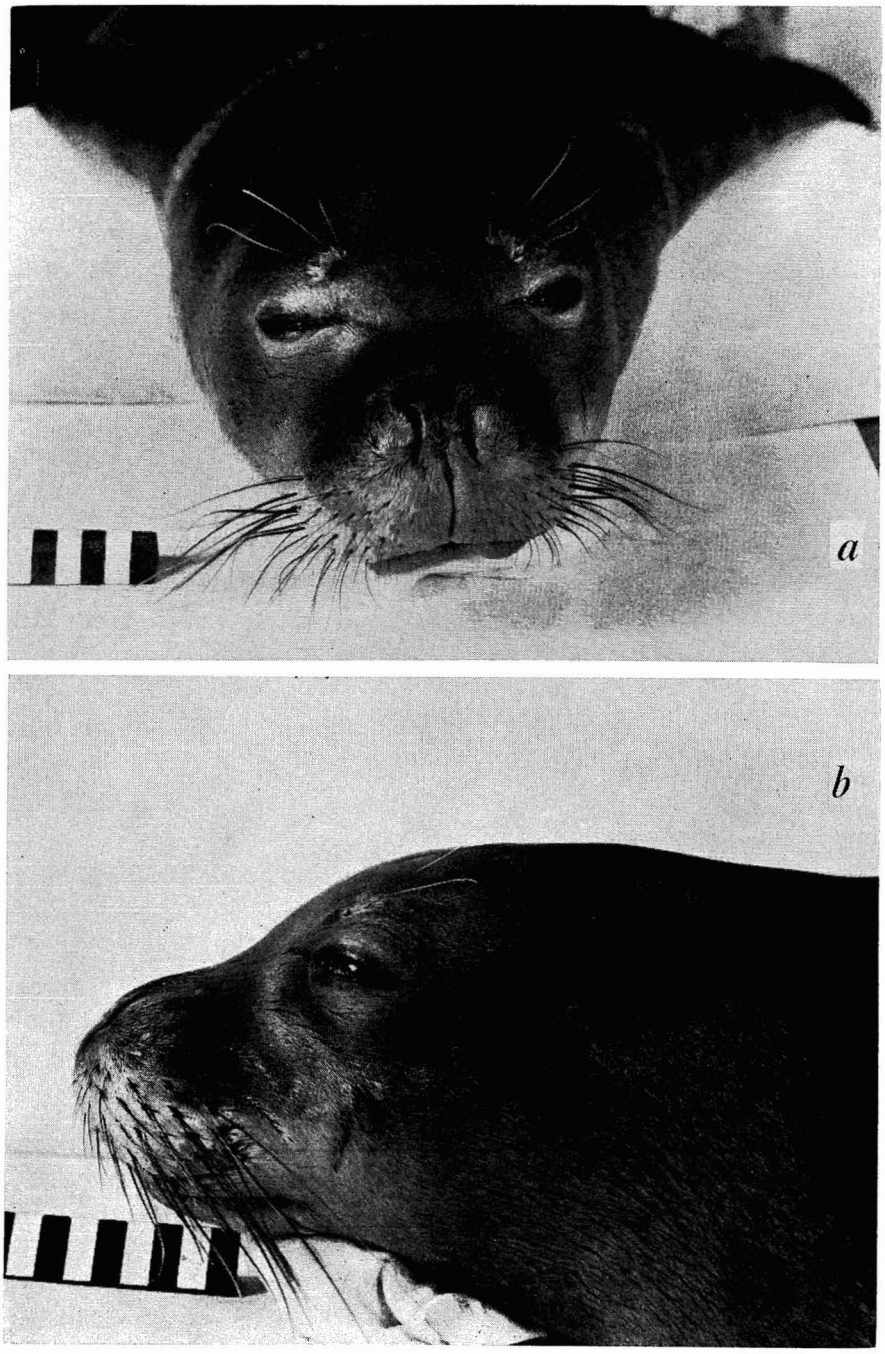

FIG. 1. *a,* Anterior view of the face of *M. schauinslandi. b,* Lateral view of the face, showing dorsal position of nostrils.

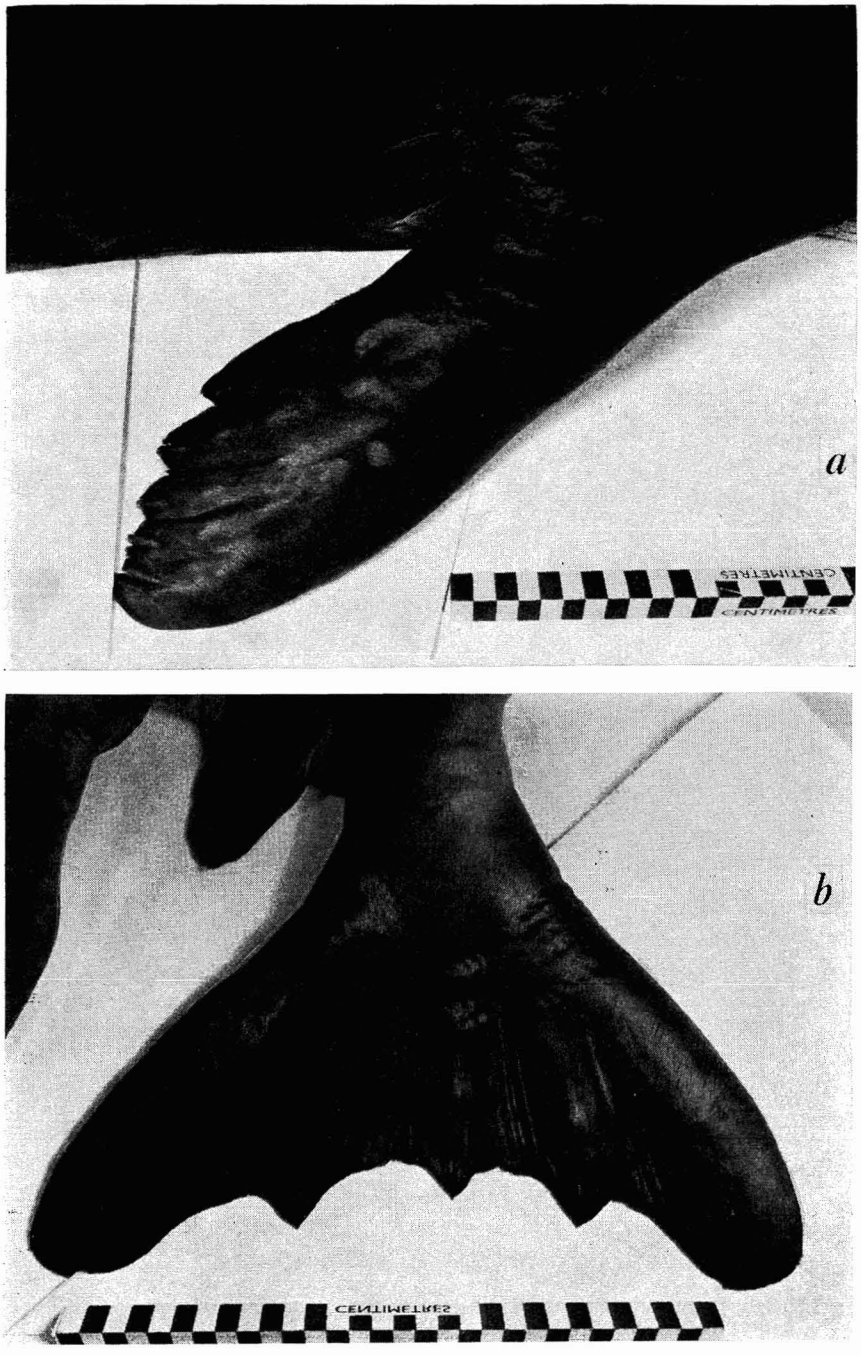

FIG. 2. *a*, Dorsal view of right fore flipper. *b*, Dorsal view of right hind flipper.

comparison are considerably limited by the youth of the specimen. The form of this description is based on that of the skeletons of *M. monachus* and *M. tropicalis* (King, 1956) and frequent reference will be made to the details in that paper. No skeleton of a young *M. tropicalis* was available so the *M. schauinslandi* skeleton was compared with that of an adult *M. tropicalis* (1887.8.5.1.) and of a young *M. monachus* (1894.7.27.3), the skull of which showed by its condylobasal length (224 mm.) and suture age (13) that it was from an animal of approximately the same size as the Laysan monk seal.

Comparison of M. schauinslandi *Skull with Those of* M. monachus *and* M. tropicalis

1. The additional measurements now available of the skull of *M. schauinslandi* confirm the previous statement (King, 1956) that skulls of both *M. schauinslandi* and *M. tropicalis* are slightly narrower in proportion to their width than those of *M. monachus,* though the accuracy of this conclusion is limited by the small number of skulls available.

	M. monachus	*M. tropicalis*	*M. schauinslandi*
	%	%	%
Zygomatic width	59.9–70.3	61.7–62.1	60.9–61.5
Snout width at canines	20.9–26.0	20.6–20.9	20.3–20.5
Width at external auditory meatus	53.1–58.5	49.8–50.5	50.5–55.0
Width at petrous bones	60.3–64.9	56.3–59.2	59.2–64.1

2. The nasal bones of this young animal are as previously described from the type skull. The anterior ends are in the form of an inverted V with the point directed posteriorly; the posterior ends do not taper as much as in *M. tropicalis.*

3. The lower edge of the infraorbital foramen is, when seen from the front, narrower than the upper edge. This confirms Matschie (1905) and is similar to *M. tropicalis.*

4. The absence of a maxillary tubercle at the anterior edge of the orbit also confirms Matschie.

5. As previously noted, the shape of the zygomatic arch is more like that of *M. monachus* than *M. tropicalis.*

6. It was noted previously that the posterior edge of the palate of *M. schauinslandi* formed a wide V. It is now felt that it is better described as U in shape and rather more like that of *M. monachus,* though there is probably a certain amount of variation in this character.

7. The pterygoid bones curve outwards as in *M. tropicalis* and in this young skull of *M. schauinslandi* they are just visible when it is viewed dorsally.

8. The coronoid process of the lower jaw is narrow and like that of *M. tropicalis.*

9. Examination and comparison of the young skull of *M. schauinslandi* now available confirms the previous report that it is more like *M. tropicalis* than *M. monachus* (Fig. 3). There are no supernumerary bones in the skull.

Kenyon and Rice (1959) note that, in the few skulls of *M. schauinslandi* they examined, the shape of the palate and the shape of the zygomatic branch of the squamosal do not appear to be constant and are thus not good distinguishing characters. It is certainly agreed that the shape of the palate is variable and there is a need for the examination of as many adult skulls as possible to determine the amount of variation.

Measurements of Skull of M. schauinslandi *1958.11.26.1*

	mm.	%
Condylobasal length	220	100
Condylobasilar length	211	95.9
Basal length	201	91.4
Basilar length	192	87.3
Snout width at canines	45	20.5
Width of skull at front end of last upper molars	59	26.8
Zygomatic width	134	60.9
Width at upper edge auditory meatus	121	55.0
Width at petrous bones (mastoid width)	141	64.1
Palatal length	101	45.9
Palatilar length	92	41.8
Width of occipital condyles	62	28.2
Length of nasal suture	50	22.7
Length of upper molar row	55	25.0

Suture age 13

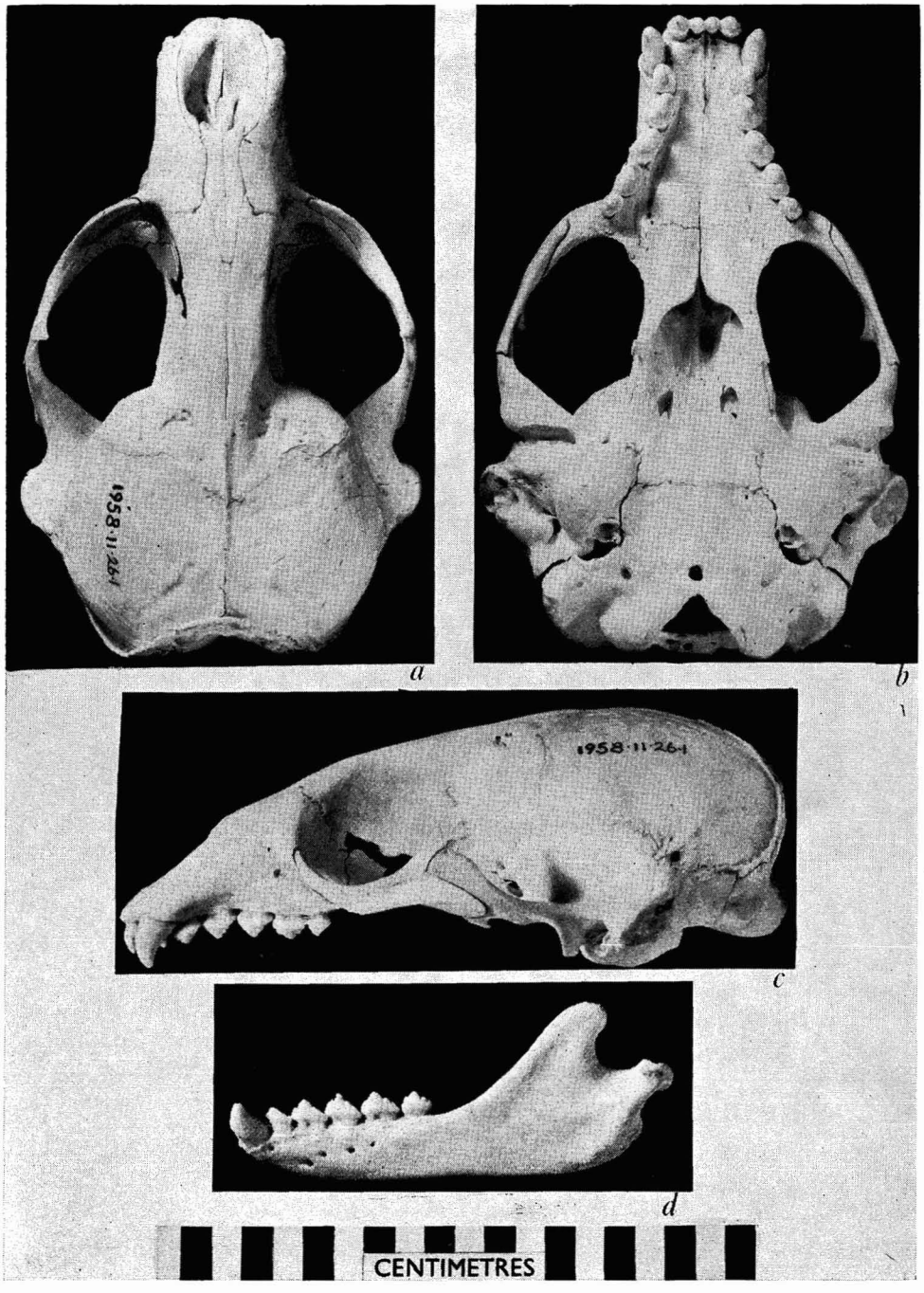

FIG. 3. *a,* Dorsal, *b,* ventral, and, *c,* lateral views of the skull of *M. schauinslandi. d,* Lateral view of lower jaw.

Teeth

Dental formula $\frac{i\ 2}{2}, \frac{c\ 1}{1}, \frac{pc\ 5}{5}$.

The term "post canines" is used here instead of "molars" and "premolars," as these latter cannot be used precisely when referring to pinniped teeth.

UPPER JAW TEETH: As previously mentioned, the upper incisors are set in a straight line across the anterior end of the premaxillae and in general the setting and shape of the teeth are like *M. tropicalis*. The incisors of this young animal do not have such a pronounced "waist" as those of the adult *M. tropicalis,* but it is more evident than in the young *M. monachus.*

The canines are very small for a male animal. Those of the young *M. monachus,* also a male, whose skull is only 4 mm. longer than that of the young *M. schauinslandi,* are much larger.

	M. monachus	*M. schauinslandi*
Anteroposterior length at crown-root junction	15 mm.	12 mm.
Anterior height of canine (in straight line from crown-root junction to tip)	23 mm.	14 mm.

M. tropicalis also has small canines. The measurements given below of the upper canines of an adult male *M. tropicalis* (1889.11.5.1; condylobasal length 267 mm., suture age 25) are compared with those of an adult male *M. monachus* of approximately similar size (1863.4.1.1; condylobasal length 273 mm., suture age 26).

	M. monachus	*M. tropicalis*
Anteroposterior length	16.5 mm.	11 mm.
Anterior height	27 mm.	est. 17 mm. (v. worn)

The height of the crown of the postcanine teeth in both *M. tropicalis* and *M. schauinslandi* is lower than in *M. monachus* and the main cusp is more rounded. In this respect *M. schauinslandi* is more like *M. tropicalis,* but in the possession of a single anterior and posterior cusp it resembles *M. monachus.* The fourth postcanine has, however, two small anterior cusps and two small posterior cusps. The surface of the teeth is more rugose than in *M. monachus* and the anterior and posterior cusps are very much less distinct, as though it is in process of losing the second posterior cusps of *M. tropicalis.* The postcanine teeth are not set obliquely.

LOWER JAW TEETH: The lower incisors are similar to those of *M. tropicalis,* the canines are small, and the postcanines are similar to those in the upper jaw.

No disease or irregularity in number is present in the teeth of either upper or lower jaws.

Skeleton

SCAPULA: The scapula of *M. schauinslandi* is very like that of *M. tropicalis.* It is similar in the way that the anterior edge is directed almost horizontally forwards from the neck before sweeping round to the dorsal surface. In *M. monachus* the anterior edge is directed forwards and upwards at an angle of approximately 45°. The spine in the young Laysan seal is represented by a low ridge with a well-developed acromion process (Fig. 4*b*).

HUMERUS, RADIUS, ULNA: No real comparison can be made because of the youth of *M. schauinslandi,* though the humerus appears to be slightly more robust than that of *M. monachus* of similar size.

MANUS: Except that the terminal phalanges are not so extensively grooved for claws as in the young *M. monachus,* although the claws themselves are of approximately similar size, the manus is not noticeably different in the three species (Fig. 4*c*).

PELVIS: The pelvis is very similar in shape to that of the young *M. monachus* although it is more mature as there is no sign of the symphysis between ischium and pubis, and the acetabulum is deep and well formed, while in the young *M. monachus* the symphysis is about half fused and the acetabulum is shallow and more obviously immature. The shape of the ischium and pubis is like that of *M. monachus* except that the pubis is possibly slightly more slender. There is no sign of the stout pubis and very narrow ischium posterior to the ischiatic spine as in *M. tropicalis.* The ilium is slightly narrower than in *M. monachus.* There is a large foramen for the obturator nerve just posterior

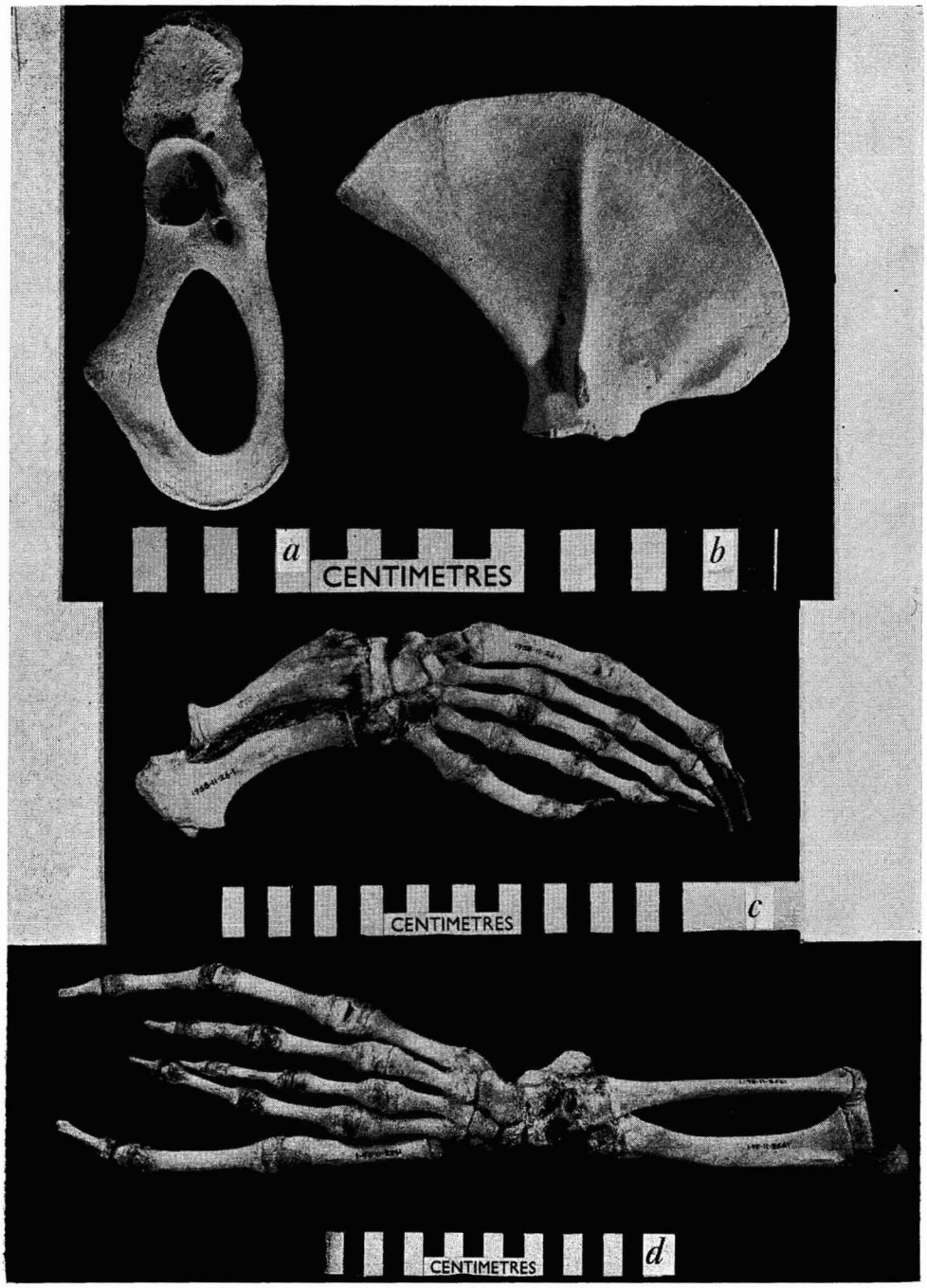

FIG. 4. *a*, Right ilium. *b*, Right scapula. *c*, Right manus. *d*, Right pes.

to the cotyloid notch that is not present in *M. monachus* or *M. tropicalis* (Fig. 4*a*).

FEMUR, TIBIA, FIBULA: These bones are not sufficiently well formed to be used for any comparison.

PES: The previous description of the pes of *M. monachus* applies also to the pes of the present animal. There is practically no indication of the insertion of the small claws on the terminal phalanges (Fig. 4*d*).

VERTEBRAL COLUMN: Vertebral formula: cervical 7, thoracic 15, lumbar 5, sacral 3, caudal 13.

Cervical vertebrae. These are more like *M. tropicalis* than *M. monachus* in that the transverse processes of vertebrae 4–6 are divided into two branches, though the division is less pronounced than in the adult *M. tropicalis.* There is a general similarity to *M. monachus,* though this is probably more because of the similarity in age. The neural arches have completely fused.

Thoracic vertebrae. These are similar to those of the young *M. monachus* except that the neural arches are narrower and do not lean so far posteriorly.

Lumbar and caudal vertebrae. These are as previously described (King, 1956).

RIBS: The articulation of the ribs is similar to that in the other monk seals. In order to inject the vascular system and remove the soft parts the cartilaginous parts of the ribs were cut away.

ABDOMINAL VEINS

The abdominal veins are thin and easily distensible. The posterior vena cava is duplicated as in *Phoca* but displays a complicated arrangement of large anastomotic channels (Fig. 5) not hitherto described in other Pinnipedia. The right limb of the posterior vena cava is the larger, is almost straight, and lies a little to the right of the midline. The smaller left limb extends from the pelvis on the left, passing somewhat obliquely cranialwards to the right to join the right limb near the upper pole of the left kidney. A large anastomotic channel passes from the right limb at the level of the lower pole of the right kidney obliquely across the midline to join the left limb at the level of the middle of the left kidney. A smaller channel arises from the right cranial end of the anastomosis just described, passes dorsal to the right limb, and enters it on the right at the level of the upper pole of the right kidney. Each limb and the two anastomotic channels receive numerous tributaries draining the renal stellate plexus as well as many vessels from the lumbar and pelvic venous plexuses. The right limb of the posterior vena cava is 2.5 cm. in diameter where it is formed by union of the iliac, lumbar, and most caudal renal tributaries. It is 3.0 cm. in diameter where it is joined by the left limb. The common trunk is 3.0 cm. in diameter throughout the 8.0 cm. of its extent to the point where it is enclosed by hepatic tissue.

The common trunk of the posterior vena cava is enlarged considerably where it enters the substance of one lobe of the multilobed liver. It has the form of a dilated tube, 15 cm. in length and 6 cm. in diameter in its cranial portion, lying on the ventral surface of the liver and surrounded on three sides by a narrow strip of hepatic tissue. Several large orifices of hepatic veins are present on the lateral walls of this dilated part of the posterior vena cava. Cranially this part of the posterior vena cava enters a hepatic sinus, nearly spherical in shape and approximately 10 cm. in diameter. The sinus is partially surrounded by hepatic tissue, but in regions only a thin translucent wall covered by peritoneum separates it from the diaphragm. The sinus is divided by two narrow septa arising from its right wall. Six large hepatic veins open into the sinus. The capacity of the sinus is estimated to be 450 cc. Figure 6 shows the appearances of the dilated vena cava and the hepatic sinus.

The intrathoracic part of the posterior vena cava is 5 cm. in length and 3.5 cm. in diameter. No pericardial plexuses of vessels, such as are found in *Phoca,* were present and no veins drained into this part of the vena cava. An incomplete sphincter of striated muscle encircles the vena cava just cranial to the diaphragm. The dorsal part of the sphincter was 3.5 cm. high and was closely adherent to the vena cava; it was separated from the diaphragmatic muscle by a narrow strip of connective tissue. The fibres of the sphincter only partially encircle the vena cava so that on its ventral aspect the sphincter is narrowed to a bundle of closely packed fibres

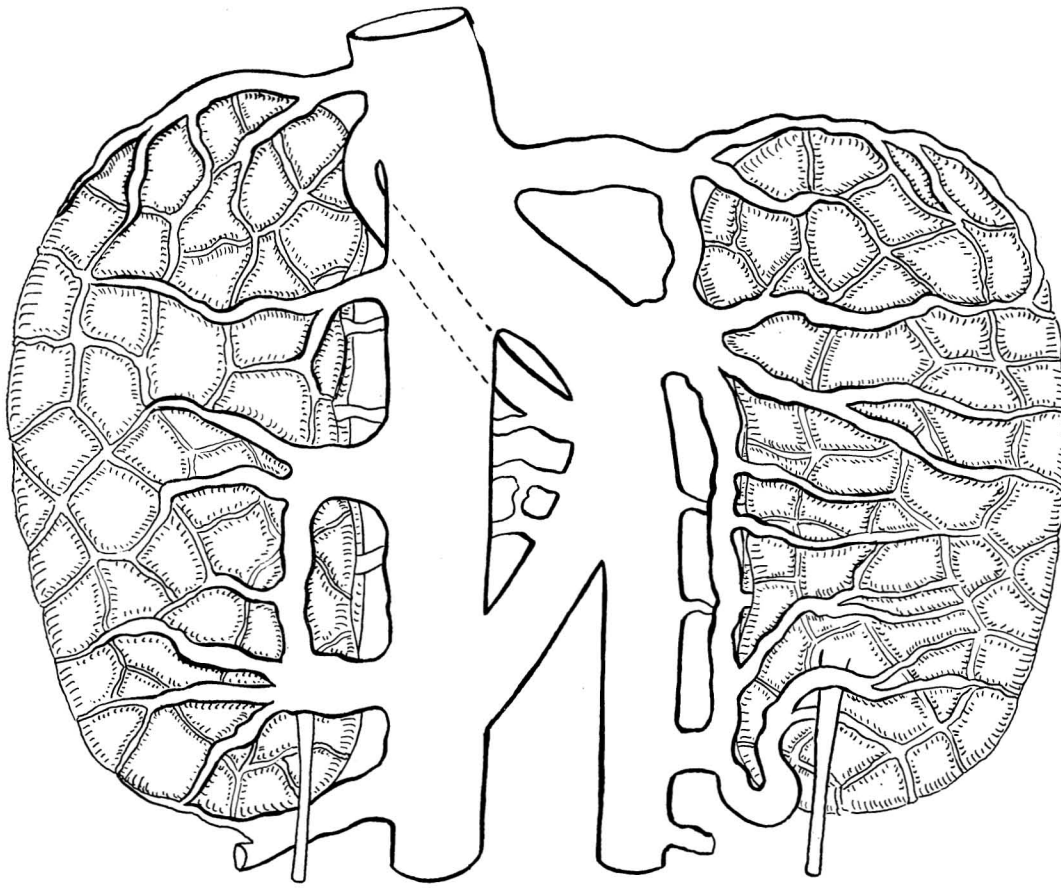

FIG. 5. A drawing from the ventral aspect to show the duplicated posterior vena cava, its anastomotic branches, and the stellate renal plexus on the surface of the multilobular kidney.

0.5 cm. high. The sphincter is shaped like a signet ring. It is supplied by branches of the right phrenic nerve.

KIDNEYS

The right kidney lies 2 cm. more cranial than the left. The right is 18 cm. long, 8 cm. broad, and 3.5 cm. thick; the left is 16 cm. long, 7 cm. broad, and 3.5 cm. thick. Each kidney is composed of large numbers of renules, each about 2.0 cm. in diameter. The papilla of each renule projects into a single calyx with a ductule that unites with others to drain eventually into the pelvis of the ureter as in *Phoca* (Harrison and Tomlinson, 1956).

Each kidney is surrounded by a stellate venous plexus, the communicating vessels of which lie in the sulci between the renules on the surface of the kidney. The plexus is more marked on the ventral aspect of the organ. There are numerous anastomoses with lumbar and lateral wall veins, with the intravertebral vein, and with the azygos vein. The plexus is drained mainly by a series of tortuous tributaries that extend round the upper and lower poles and transversely across the ventral and dorsal surfaces of the body of the kidney. These tributaries unite at the medial border of each kidney to form three or four short trunks that enter the two main limbs of the posterior vena cava or its large anastomotic

channels (Fig. 5). The major portion of venous blood is conveyed by interlobular veins reaching the surface between renules to enter the stellate plexus. Some interlobular veins, however, pass towards the hilum of the kidney to drain into small channels that extend medially to the limbs of the posterior vena cava.

HEART AND GREAT VESSELS

The aorta is markedly constricted at a point immediately to the left of the origin of the left subclavian artery and below the ductus arteriosus. This condition is known as coarctation (*coarctus* = pressed together) and is the result of partial obliteration of the dorsal aorta either between the 4th and 6th arch (above the ductus arteriosus) or below the 6th arch and the dorsal aorta (below the ductus arteriosus). It occurs rarely in man: Wood (1956) found coarctation of the aorta in 9 out of 900 cases of congenital heart disease. It appears to be very rare indeed in mammals and has not been reported in any animals dying at the Zoological Gardens, Regent's Park, London (R. W. Fiennes, personal communication). Cordy and Ribelin (1950) describe its occurrence in a bullock associated with dextraposition of the heart. It occurs, in man, more frequently in males (4.5:1), is most often found in young adults and 1 per cent of the cases have hereditary links (Wood, 1956).

FIG. 6. A drawing from the right side of a sagittal section through the dilated intrahepatic part of the posterior vena cava, the hepatic sinus, and the sphincter about the intrathoracic part of the vena cava. The hepatic sinus is divided by thin, falciform septa; the main openings of the hepatic veins are shown as black circular areas.

The transverse diameter of the monk seal aorta at the point of coarctation is 1.0 cm., that of the first part of the descending aorta is 1.4 cm. There does not appear, therefore, to be any post-stenotic dilatation of the aorta as is often found in man. The ascending aorta and its arch are dilated with marked thickening of the wall. The most dilated part is 4.5 cm. in diameter; the thickened wall is 3.0 mm. thick as opposed to the wall of the descending aorta, which is 1.0 mm. thick. At the point of coarctation the wall of the aorta is thickened by fibrous tissue to 4.0 mm. cranially and to 3.0 mm. caudally; the other parts of the aortic wall are less thick. Three aortic valves are present (only two are present in 23 per cent of human subjects with coarctation, Hamilton and Abbott, 1928). The aortic ring appears of normal size (aortic stenosis is present in 7.5 per cent of cases in man).

The left ventricular musculature appears hypertrophied, but otherwise the heart is normal. There is no patent foramen ovale and the ductus arteriosus is closed (7 per cent of human cases show a patent ductus). The right and left atria appear to be of normal size and have walls that do not look hypertrophied. There is no evidence of enlargement of vessels that provide collateral circulations above and below the constriction (internal mammary arteries). No notching of the posterior margins of the ribs (which can be caused by raised blood pressure in the intercostal vessels) is present. The lack of any such findings could well be due to the immaturity of the animal.

OTHER VEINS

A large azygos vein is present just to the right of the midline; it is 1.25 cm. in diameter and terminates in the anterior vena cava. No left-sided azygos vein is present.

An extradural intravertebral vein is present; at the level of the 12th thoracic vertebra it lies to the left of the cauda equina. At this level it measures 1.75 cm. by 1.25 cm. It is somewhat larger at the level of the 3rd thoracic vertebra. The poor preservation of the specimen prevented detailed examination of the connexions of the vein. It definitely has connexions with the azygos vein and with the lumbar veins related to the stellate renal veins at the lower poles of the kidneys as in *Phoca.* These are clearly shown after the venous system had been injected with coloured gelatin.

LUNGS

Superficial examination (no casts were made) suggests that the arrangement of the bronchial tree is symmetrical as has been described in other seals (Brown, 1958). Histological examination reveals the presence of numerous features described by Pizey (1954) in the lung of *Phoca.* The cartilages of the tertiary bronchi are continued far to the periphery of the lung, and bronchial mucous glands are frequent. The lung is divided into numerous lobules by well-marked septa of loose connective tissue. The bronchioles possess a series of myo-elastic valves which are similar to those of *Phoca* but not as marked as those in *Tursiops* (Wislocki, 1929).

TESTIS

Each testis weighs 1.9 g. and measures 25 × 15 × 10 mm. in its greatest diameters. The seminiferous tubules are inactive, immature, devoid of lumina, and average 50/μ in cross-sectioned diameter. The interstitial tissue is relatively abundant. Some of its cells are large, polyhedral, and heavily vacuolated, but the majority are small, fusiform, and have densely stained nuclei. The connective tissue between the seminiferous tubules is loosely arranged and oedematous. These appearances suggest that the gonad may well have been precociously enlarged at birth with hypertrophy of the interstitial tissue as has been described in *Halichoerus, Phoca,* and *Mirounga* (see Harrison, 1960, for references).

DISCUSSION

It is difficult to come to any definite conclusions from the examination of this skeleton of *Monachus schauinslandi,* not only because of the lack of comparative material but also because of the extreme youth of the animal. It is obvious that it is more closely related to *M. tropicalis* than to *M. monachus* but this is to be expected because of its geographical position. Kenyon and Rice (1959) suggest that further study may indicate a closer relationship between the Laysan and the West Indian monk seals and that *M. schauinslandi* may possibly be a race of *M. tropicalis.*

The Laysan monk seal possesses certain vascular (venous) modifications seen in other Pinnipedia. These are a duplicated posterior vena cava, a stellate renal plexus, a caval sphincter, a hepatic sinus, and an extradural intravertebral vein (Harrison and Tomlinson, 1956). There are, however, certain differences. The pattern of duplication of the posterior vena cava is more complicated than in any seal so far described. There is evidence of persistence of several anastomotic channels between the two limbs of the posterior vena cava. This could be interpreted as persistence of an embryonic state in which primitive anastomoses have become enlarged rather than suppressed. The hepatic sinus is not as large as in *Phoca* or *Mirounga,* whereas the curious dilatation of the intrahepatic part of the vena cava is undescribed in seals. The sphincter is not as large or as complete as in other Pinnipedia. It could be argued that the monk seal shows less vascular (venous) specialization than *Phoca, Mirounga, Leptonychotes, Lobodon, Halichoerus,* and *Hydrurga,* but more than *Zalophus.* This could mean that monk seals are not able to dive for so long a period or as deep as these forms. No observations have been made on the diving abilities of the Laysan monk seal, but Kenyon and Rice (1959) note that these seals occur regularly only on islands having extensive areas of shallow shoal water and that they appear to feed primarily on bottom-living fishes that they could obtain only in shallow water. They do travel over deep water, though not necessarily at any great depth. It must, however, be emphasized that the specimen described here had coarctation of the aorta. We are not

certain that its venous pattern is that prevailing in all Laysan monk seals, and it is frustrating that the first whole specimen available for examination should be congenitally abnormal.

It is hoped that continuing interest in this rare and relatively unknown seal will, in due course, result in the acquisition of more specimens for study. In the meantime it has been a great pleasure to see and work on the present animal and we are much indebted to Mr. Vernon E. Brock and his fellow workers for their kindness. We are also grateful to Dr. J. D. W. Tomlinson for injecting the specimen and for making some initial observations.

SUMMARY

A young male monk seal *Monachus schauinslandi* of an estimated age of 5 weeks has been received by the British Museum (Natural History). A brief description is given of the external features, stomach contents, and parasites. The skull and skeleton are described and a general similarity to that of *M. tropicalis* is noted. Certain modifications in the venous system are described; coarctation of the aorta is present.

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